

Atty. Docket No. OPP030889US
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Remarks

Applicant and his representatives wish to thank Examiner Nadav for the thorough examination of the present application, the clear explanations in the Final Office Action dated January 19, 2006, and for the very helpful and courteous discussion held with their undersigned representative on March 23, 2006. Figures 1A-1F have been amended to show the barrier metal layer, as discussed. The following remarks shall further summarize and expand upon topics discussed.

Claims 1-2, 4-5, and 8 have been amended. Claims 6-7 have been canceled. Claims 9-20 have been previously canceled. Claims 21-34 have been added. Therefore, Claims 1-5, 8, and 21-34 are active in this application. No new matter is introduced by the present Amendment.

The present invention relates to a semiconductor device comprising:

- a) a via over a semiconductor substrate;
- b) a barrier metal layer on a surface of the via;
- c) a metal line in the via over the barrier metal layer; and
- d) an alloy layer on an upper surface of the metal line, wherein the alloy layer comprises a metal of the metal line and a low melting point metal having a melting point less than or equal to 1000°C. (see Claim 1 as amended above)

The cited references do not disclose or suggest, alone or taken together, a semiconductor device including an alloy layer on an upper surface of a metal line in a via over a barrier metal layer. Thus, the present claims are patentable over the cited references.

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The Rejection of Claims 1-3 and 5-6 under 35 U.S.C. § 102(e)

The rejection of Claims 1-3 and 5-6 under 35 U.S.C. 102(e) as being anticipated by Liu et al. (US 6,638,867, hereinafter "Liu") is respectfully traversed.

Claim 1 is exemplified by a structure as shown in Figure 1F, including an alloy layer 5 on an upper surface of a metal line 3 (see paragraph [0014] of the present specification) in a via 100 over a barrier metal layer 10 (see paragraphs [0011]-[0012] of the present specification), wherein the alloy layer 5 comprises a metal of the metal line 3 and a low melting point metal having a melting point less than or equal to 1000°C (see paragraph [0009] of the present specification).

Liu discloses a bonding pad 60 that includes an aluminum alloy bonding pad segment 54 in a shallow interconnection line 40 (see col. 6, ll. 16-27, and FIGS. 6C-6D) and an aluminum conductive layer 58 over the bonding pad segment 54 (see col. 6, ll. 34-42, and FIG. 6C). Liu fails to disclose a barrier metal layer on a surface of the via and a metal line in the via over the barrier metal layer, as recited in Claim 1.

Liu discloses that the conductive layer 58 over the bonding pad segment 54 can alternatively consist of aluminum alloy, tungsten, copper, or a copper alloy (see col. 6, ll. 35-40). Aluminum has a melting point below 1000° C. An aluminum alloy conductive layer 58 on bonding pad segment 54 could, in theory, be the claimed alloy. However, Liu does not appear to teach or disclose that the non-aluminum metal in the aluminum alloy is the same as a metal in bonding pad segment 54 (see col. 6, ll. 34-40). Similarly, the copper alloy alternative for conductive layer 58 could be the claimed alloy, but there is no indication in Liu that the copper alloy is an alloy of copper and aluminum (see col. 6, ll. 34-40). It is therefore believed that Liu does not disclose an alloy layer comprising both a low melting point metal having a melting point less than or equal to 1000° C and a metal of a metal line, assuming for the sake of argument that bonding pad segment 54 constitutes a metal line.

On the other hand, if one selects aluminum or aluminum alloy for conductive layer 58 and a different metal or alloy for bonding segment 54, bonding pad segment 54 and conductive layer 58 could, in theory, form the claimed alloy. However, the bonding pad 60 disclosed by Liu

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includes shallow trench 40 that only partially penetrates insulative layer 134 (see col. 5, ll. 55-64, and FIG. 5A). Therefore, the metal feature 54 in shallow trench 40 is not in a via (see FIGS. 6A-6D), and bonding pad 60 cannot read on the device of Claim 1, which recites a device that includes a metal line in a via over a semiconductor substrate.

Liu does disclose a metal feature 50 in a via (col. 6, ll. 16-24). However, it is not included in the structure of bonding pad 60, and no metal or metal alloy is on an upper surface thereof. Therefore, Liu does not anticipate the device of Claim 1, and the rejection under 35 U.S.C. § 102(c) should be withdrawn.

Claims 2-3 and 5 depend from Claim 1, and thus include all of the limitations of Claim 1. Therefore, Claims 2-3 and 5 are patentable over Liu for essentially the same reasons as Claim 1.

Claim 6 has been canceled. Thus, the rejection under 35 U.S.C. § 102(c) has been obviated and should be withdrawn.

The Rejection of Claim 4 under 35 U.S.C. § 103(a)

The rejection of Claim 4 under 35 U.S.C. § 103(a) as being unpatentable over Liu is respectfully traversed.

To establish a prima facie case of obviousness, three basic criteria first must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. See MPEP §2143.

Liu discloses a bonding pad 60 (see, e.g., FIG. 6D) as the only apparent structure that could include an alloy layer as recited in Claim 1. As explained above, bonding pad 60 is a different structure than the device in Claim 1, which comprises an alloy layer on an upper surface of a metal line in a via over a barrier metal layer. Without some suggestion or motivation from Liu, those of ordinary skill in the art would not modify the structure of bonding

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pad 60 to form bonding pad segment 54 in a via. Liu does not provide any such suggestion or motivation. Therefore, there would be no motivation to modify Liu or combine Liu with other references to arrive at a device as recited in Claim 1. Therefore, Claim 1 is patentable over Liu.

Claim 4 depends from Claim 1, and thus includes all of the limitations of Claim 1. Therefore, Claim 4 is patentable over Liu for essentially the same reasons as Claim 1, and the rejection under 35 U.S.C. § 103(a) should be withdrawn.

The Rejection of Claim 7 under 35 U.S.C. § 103(a)

The rejection of Claim 7 under 35 U.S.C. § 103(a) as being unpatentable over Liu in view of Stumborg et al. (US 6,077,775, hereinafter "Stumborg") is respectfully traversed.

As explained above, Liu fails to disclose or suggest a device that includes an alloy layer on an upper surface of a metal line in a via over a barrier metal layer, as recited in Claim 1. Furthermore, Liu does not provide any suggestion or motivation to modify the structures therein to arrive at the structure recited in Claim 1. Therefore, Liu is deficient with regard to the present Claim 1.

Stumborg discloses a semiconductor device including a barrier diffusion barrier 49 lining the sidewall of a via hole and a copper plug 45 in the via hole (see col. 12, ll. 36-45, and FIG. 8). Stumborg does not recite an alloy layer over the copper plug 45, and thus fails to cure the deficiencies of Liu with regard to an alloy layer on an upper surface of a metal line in a via over a barrier metal layer, as recited in Claim 1.

Furthermore, one of ordinary skill in the art would not be motivated to combine the copper plug 45 in a via hole over a diffusion barrier layer 49 with the bonding pad 60 of Liu. Liu and Stumborg disclose different structures. Liu discloses both a bonding pad structure 60 that is not in a via, and a separate interconnection structure including a metal feature 50 in a via. Stumborg discloses a device having a copper plug 45 in a via hole with no bonding pad structure thereon or thereover. One of ordinary skill in the art might be motivated to combine the features of Stumborg with the interconnection structure 50 of Liu because they are similar structures.

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However, as explained above, there is no motivation or suggestion in either Liu or Stumborg to combine the bonding pad 60 of Liu with the metal structure in the via of Stumborg to form a device that includes a via within which the bonding pad segment 54 of Liu would be formed. Therefore, Stumborg fails to cure the deficiencies of Liu, and Claim 1 is patentable over Liu in view of Stumborg.

Claim 7 has been canceled. Thus, the rejection under 35 U.S.C. § 103(a) has been obviated and should be withdrawn.

The Rejection of Claim 7 under 35 U.S.C. § 103(a)

The rejection of Claim 7 under 35 U.S.C. § 103(a) as being unpatentable over Liu in view of Lee et al. (US 6,551,856, hereinafter "Lee") is respectfully traversed.

As explained above, Liu fails to disclose or suggest a device that includes an alloy layer on an upper surface of a metal line in a via over a barrier metal layer, as recited in Claim 1. Furthermore, Liu does not provide any suggestion or motivation to modify the structures therein to arrive at the structure recited in Claim 1. Therefore, Liu is deficient with regard to the present Claim 1.

Lee discloses a structure, as shown in FIG. 4, including a copper bonding pad 50 in a bonding pad opening 44 (see col. 6, ll. 30-34) and copper in a redistribution via 68 over the copper bonding pad 50 (see col. 6, ll. 53-59). Lee discloses neither an alloy layer over a metal line nor a metal line over a barrier metal layer in a via. Lee fails to disclose an alloy layer on an upper surface of a metal line in a via over a barrier metal layer, as recited in Claim 1. Therefore, Lee fails to cure the deficiencies of Liu with regard to the structure recited in Claim 1, and Claim 1 is patentable over Liu in view of Lee.

Claim 7 has been canceled. Thus, the rejection under 35 U.S.C. § 103(a) has been obviated and should be withdrawn.

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Conclusions

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,



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